

(12)

(19)

(11)

2 166 775 A

(21) Application No 8422975

(22) Date of filing **12 Sep 1984**

(71) Applicant
Britoil PLC (United Kingdom),
Centenary House, 100 Morrison Street, Glasgow G5 8LP

(72) Inventors
Peter John Doyle
Anthony Frank Pipe

(74) Agent and/or Address for Service
Marks & Clerk,
57-60 Lincoln's Inn Fields, London WC2A 3LS

(51) INT CL⁴
E21B 33/03 33/04

(52) Domestic classification
E1F JR

(56) Documents cited

GB A 2058881	GB 1419849	GB 1407736
GB A 2030620		

(58) Field of search
E1F
Selected US specifications from IPC sub-class E21B

(57) An underwater well head 1 is provided with a tree body 3 in which a tubing hanger 5 is directly seated and housed. The tubing hanger has lateral supports 10 aligned with ports 11 in the tree body, and control valves 14, 15 are mounted directly in the tree body. The tubing hanger also has a vertical through passage 9 of the same diameter as the tubing 7, for providing in-line access, normally closed by a crown plug 20. In normal operation, produced or injected fluid passes through the ports 11, sealing being provided by upper and lower peripheral seals 8 on the tubing hanger. Above the tubing hanger is primary tree cap 16 with electrical and hydraulic connectors interfacing with the tubing hanger. On the primary cap 16 is a workover cap 17 providing for wire line access.

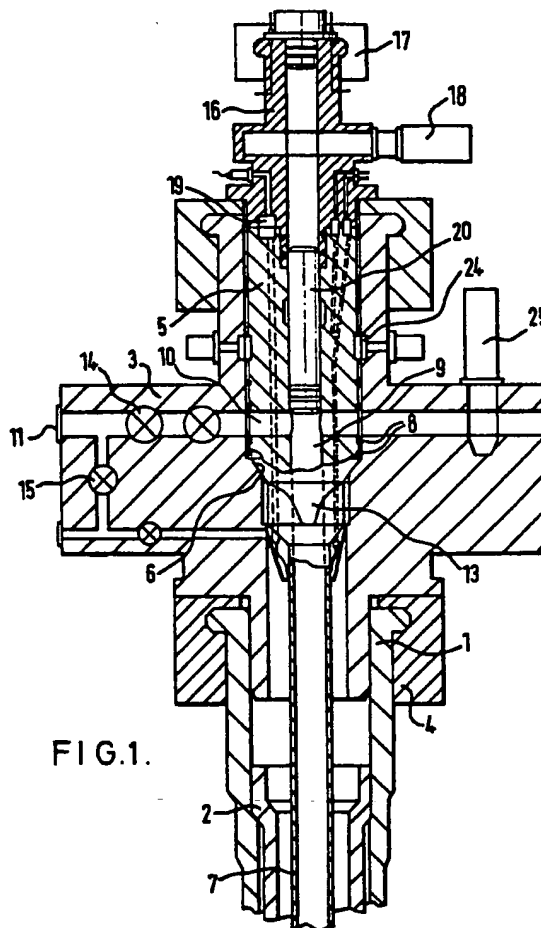


FIG. 1.

GB 21667/5 A

2166775

1/2

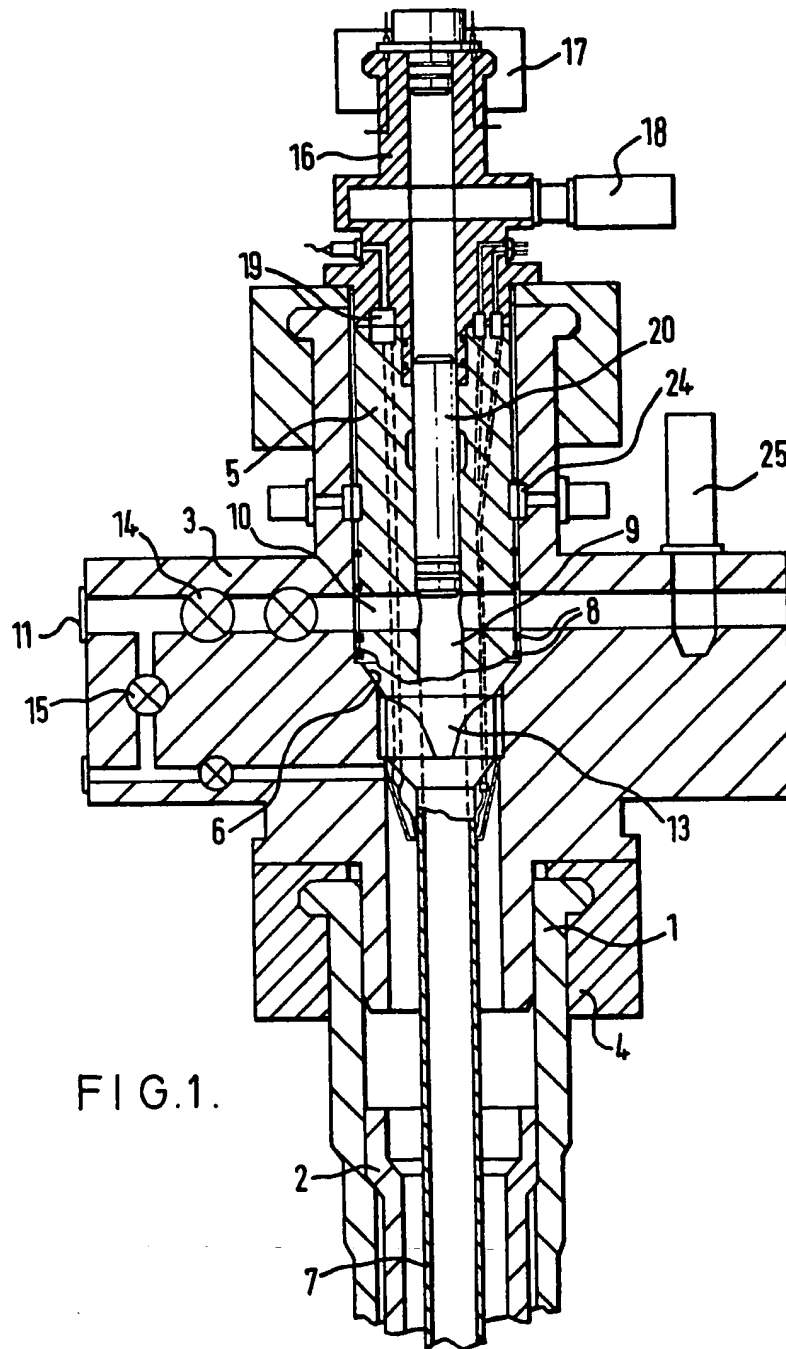


FIG. 1.

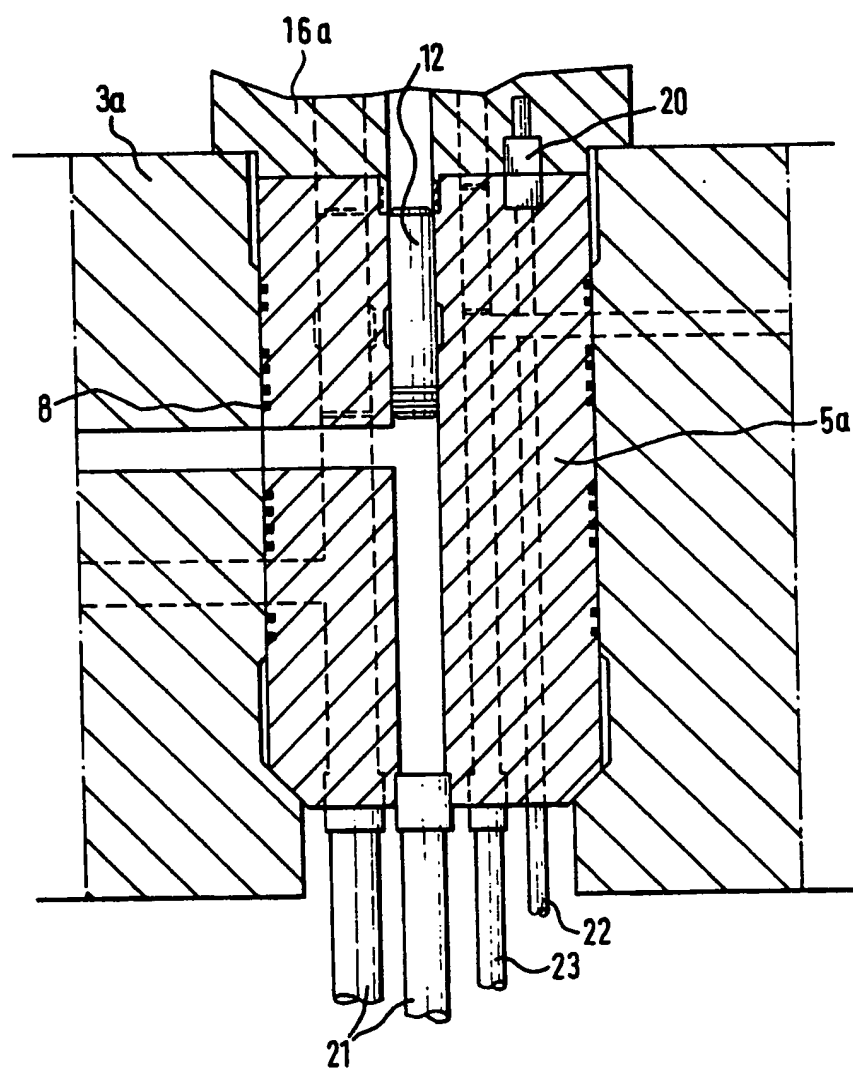


FIG.2.

SPECIFICATION

Underwater well equipment

5 This invention relates to underwater well held equipment, and in particular to a novel tree.

In conventional well heads, the tubing hanger is seated in the well head body, onto which the tree is mounted. This arrangement
10 has numerous practical disadvantages: the size of the valves in the tree is determined by the size of the tubing and tubing hanger, and access to electrical and hydraulic connectors for downhole equipment is difficult.

15 There is a requirement for a well head and tree system which will allow through-tree tubing operation.

A tree system produced by National Supply consists of a production upper body, a well
20 head connector, and a main tree body. The upper body carries the well head connector, tubing hanger landing profile, and tubing hanger lockdown system. It is ported for downhole safety valve control line, and a side-entry
25 annulus connection. It allows unrestricted passage for downhole tubing and associated equipment. Tree valves are situated above the tubing hanger.

This system has a number of disadvantages.
30 The valve actuators are large; sealing surfaces in the tree are liable to damage during installation of the tubing; the system does not lend itself readily to vertical annulus access or dual-string arrangements; the provision of extra
35 downhole facilities is not readily provided for; there is only limited space at the interface between the tubing hanger and tree, which hampers the provision of downhole equipment connectors such as electrical instrumentation
40 contacts; there is a risk of contamination of downhole safety valve control lines; high point loadings can arise at the tree/tubing hanger interface.

The Hydril completion diverter has a diverter
45 valve above the tubing hanger, which can be set to divert flow laterally through master valves, or alternatively can permit straight-through vertical access. The diverter valve contains an insert which can be removed to
50 provide large-diameter vertical access so that the tubing hanger, tubing and packer can be run through the valve. With this system, conventional-sized valves and actuators can be used and valves can be integrated with the
55 tree body. However, the relatively complex diverter valve arrangement requires special sealing at the tubing hanger and ball valve interface, and sealing faces and seals may be prone to damage during installation or workover
60 operations if the valve ball is not correctly aligned. Owing to limited space and the movement of the valve ball, the provision of hydraulic and electrical connections for downhole equipment at the interface between the tree
65 and tubing hanger is not easy.

An object of the present invention is to provide an arrangement in which through vertical access of full diameter is provided, and electrical and hydraulic connections for downhole
70 equipment can be provided relatively easily, in a simple and reliable structure.

According to the present invention, the tubing hanger is seated in the tree body. Access to the tubing is laterally, through passages
75 provided in the tubing hanger and tree body. The tubing hanger can also provide in-line vertical access to the tubing. Preferably, the upper end of the tubing hanger is at or near an upper surface of the tree body, providing a
80 readily accessible interface for connections of various kinds.

The present invention is illustrated by the accompanying drawings in which:

Figure 1 is a vertical section through a well
85 head and tree assembly embodying the invention, and

Figure 2 shows, on a larger scale, a possible multi-string tubing hanger.

Figure 1 shows a conventional well head 1
90 and a conventional casing 2. A tree body 3 embodying the invention is mounted on the well head by a connector 4.

A tubing hanger 5 is seated on a load bearing shoulder 6 in the tree body, so that the
95 tubing hanger is housed in the upper part of the tree body.

The tubing hanger has a cross-ported manifolded top section which forms part of the tubing hanger body, which in turn is an integral part of the downhole tubing 7. It is provided with main seals 8 to seal it in the cylindrical seat in which it is located in the tree
100 body.

The tubing hanger has an axial through passage 9 of the same diameter as the tubing. In the lower part of the tubing hanger, between upper and lower main seals 8, the passage 9 communicates with lateral ports 10 which in turn communicate with outlet ports 11 in the tree body. The bore 9 is normally closed above the ports 10, by a crown plug 12. During normal operation, produced or injected fluid is diverted through 90°, through the outlet ports 11 in the tree body. The seals 8
105 required to isolate the ports are installed with the tubing hanger assembly.

The tubing hanger and tree body are provided with a hanger orientation cam and slot arrangement 13. For a single string installation, a non-orienting system may be used to instal the tubing assembly into the tree body. For multi-string use, an orientation mechanism is of course essential.

The tree body provides the load bearing
125 seat 6, the lock down system 24 and mating sealing faces for the tubing hanger, and is provided with the fluid ports and production wing and crossover valves as necessary. Figure 1 shows master valves 14 and an annulus crossover valve 15 providing communication
130

with the well annulus, and vertical or horizontal actuators 25. The tree body may be configured to permit vertical mounting of valves, actuator and flowline connections, thereby simplifying subsea installation and removal of such components.

The lower half of the tree body is configured to mate with the well head, while the top of the tree body interfaces with the primary tree cap 16 or, during workover, with the BOP and main riser system.

Mounting the valves in the tree body provides protection from external damage. There is no need for the conventional separate tree insert, and it is not necessary to use large valves or actuators, regardless of the casing size or the outside diameter of the tubing hanger. For example, conventional three inch valves can be used.

The tree cap, unlike conventional arrangements, is split into two sections. The main or primary section 16, interfaces with the tree body 3 and provides secondary load and pressure containment of the tubing hanger. When tubing removal is necessary the primary cap is removed and replaced with the BOP and riser assembly. The secondary tree cap 17, which is mounted onto and forms part of the primary tree cap, provides a smaller access and mounting location for a small wireline BOP system thus simplifying requirements for general wireline workover and re-entry. A swab valve 18 mounted in the primary cap section ensures additional safety during the wireline operation and secondary tree cap removal. This is backed up by the wireline removable crown plug 12 in the top entry part of the tubing hanger manifold body.

The upper end face of the tubing hanger is very close to the top of the tree body, where it forms an interface with the primary tree cap 16. At this interface, electrical connectors 19 and hydraulic connectors 20 are provided. This provides an improved environment for instrument and downhole pump electrical connectors, and better access to such connectors, to permit diver, ROV or self-aligning coupler make-up after the tree body has been installed.

An analogous construction can be used for a multi-string installation. By way of example only, Figure 2 shows a tubing hanger 5a with primary and secondary seals 8 and adjoining parts of the tree body 3a and primary tree cap 16a, for an installation comprising two production strings 21 as well as electrical instrument cables and lines 22, and hydraulic lines 23 to a downhole pump.

The configuration proposed is ideal for single satellite and twin cluster well applications. It can also be modified for use with TFL systems and top entry fluid connection systems such as may be required on a template/manifold application.

As the tree permits a high level of functions

at the tubing hanger interface the benefit of multizone production, artificial lift and improved instrumentation accommodation could be employed for platform based wells.

The proposed tree fulfils two functions necessary for economical and efficient subsea oil production. These functions are:

The ability to remove the downhole tubing system and its components without disturbing the tree and its associated interfaces.

The ability to accommodate tubing assemblies for multizone production and TFL servicing plus downhole equipment such as gas lift valves, artificial lift pumps and electronic instrumentation.

Obviously the more complex the downhole system becomes the more likely it is that servicing will be necessary. The ability to remove and service the equipment quickly and easily is therefore essential. The configuration proposed covers these aspects.

A summary of the features of the proposed design is as follows:

Permits safe withdrawal of tubing and hanger without removing the tree, thus allowing complex downhole equipment requiring regular maintenance to be used.

Permits any size of tree valve to be used regardless of the tubing and casing size.

As the tree valves do not govern the size of the tubing hanger its size may be increased to accommodate any number of downhole tubing strings.

Similarly the areas required to mount electrical and hydraulic connectors for downhole equipment, can be provided.

Provides good access to the mounting interface with electrical, instrumentation hydraulic and downhole service connections.

Permits use of standard BOP and riser assemblies.

Permits orientation of tubing.

Offers a low tree profile.

Permits vertical positioning of valves and connectors to assist in subsea intervention, installation or removal.

Allows safe disconnection of the tree cap.

Can be configured for use as single satellite tree or as an integral installation on a template/manifold system.

Can be adapted for platform use.

Vertical access to the annulus is also obviously possible.

As the tree cap is divided into two sections the use of a smaller wireline BOP is possible thus eliminating heavy equipment requirements for routine surface vessel intervention.

CLAIMS

1. A well head comprising a tree body, a well tubing hanger seated in the tree body, and at least one lateral passage provided in the tree body and in the tubing hanger providing access to the tubing.

2. A well head according to claim 1 in

which the tubing hanger provides direct in-line vertical access to the tubing.

3. A well head as claimed in claim 1 or 2 in which the upper end of the tubing hanger is at
5 or adjacent an upper surface of the tree body.

4. A well head as claimed in claim 1, 2 or 3 in which the tubing hanger is provided with peripheral seals above and below the lateral access passage or passages.

10 5. A well head as claimed in any preceding claim, in which flow control valves for produced or injected fluid are provided within the tree body.

6. A well head as claimed in any preceding
15 claim having a tree cap, which cap comprises two portions of which a primary portion interfaces with the tree body and provides containment for the tubing hanger, and a secondary portion mounted on the primary portion
20 and adapted to provide for wireline access.

7. A well head as claimed in claim 6 having electrical and/or hydraulic connecting means at an interface between the primary portion of the cap and the upper end face of the tubing
25 hanger.

8. A well head, substantially as herein described with reference to Figure 1 or Figure 2 of the accompanying drawings.

(12) UK Patent Application (19) GB (11) 2 226 063⁽¹³⁾ A

(43) Date of A publication 20.06.1990

(21) Application No 8910761.9

(22) Date of filing 10.05.1989

(30) Priority data

(31) 06661

(32) 16.12.1988

(33) BR

(51) INT CL⁴

E21B 43/017 7/128

(52) UK CL (Edition K)

E1F FBC FJB

(56) Documents cited

None

(58) Field of search

UK CL (Edition J) E1F FBC FJB

INT CL⁴ E21B

(71) Applicant

Petroleo Brasileiro S A - Petrobras

(Incorporated in Brazil)

Avenida Republica do Chile, n°65 Rio de Janeiro,
Brazil

(72) Inventors

Andre Lima Cordeiro

Helio Lins Marinho Falcao

Renato Sanches Rodrigues

Samir Passos Awad

(74) Agent and/or Address for Service

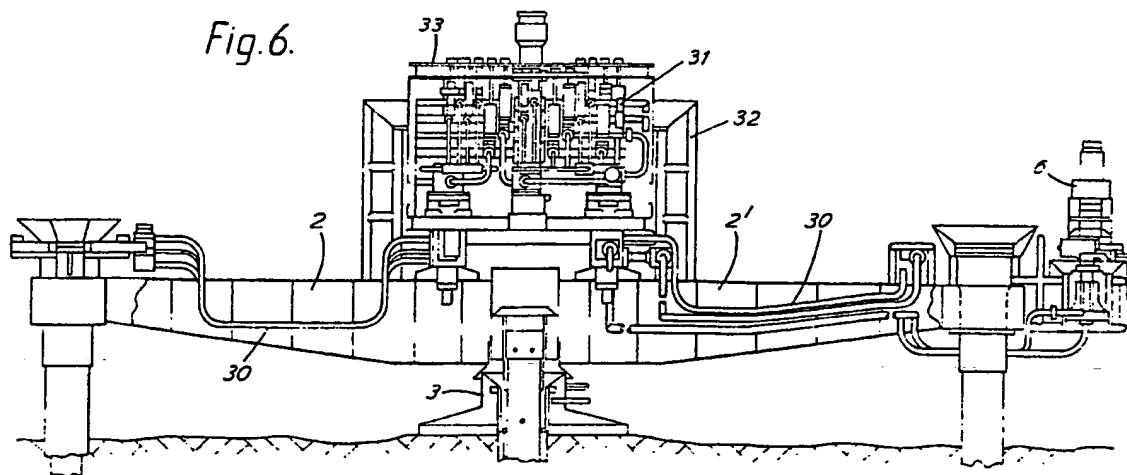
J A Kemp and Co

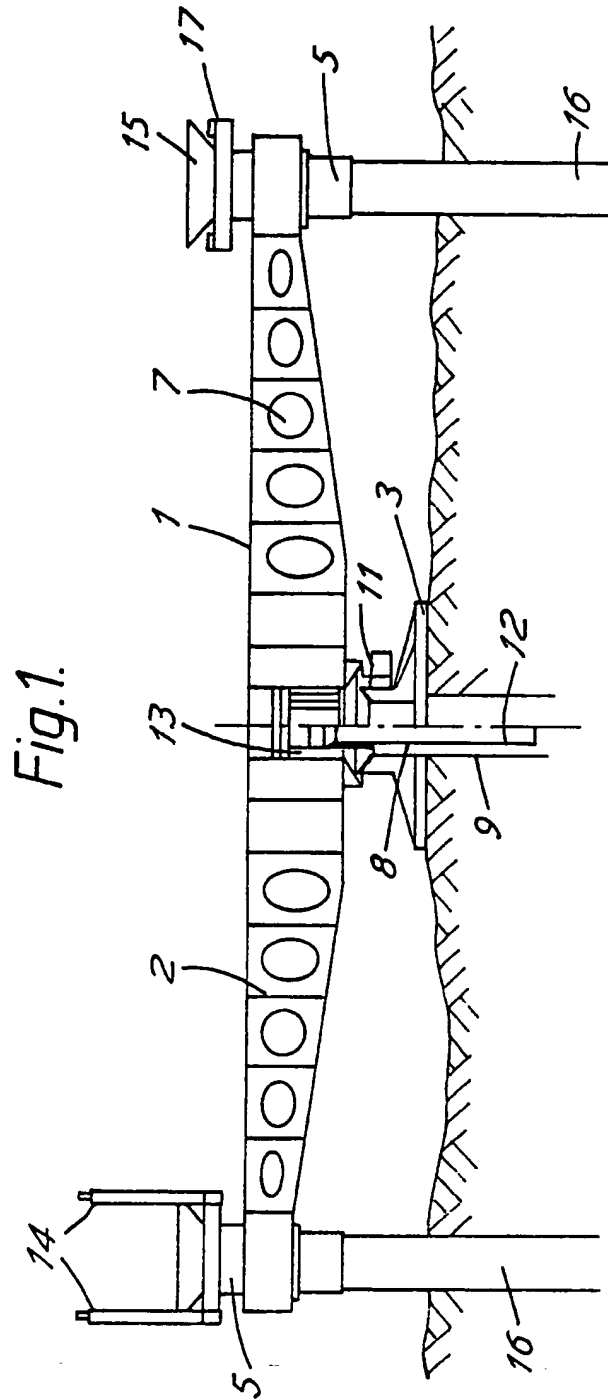
14 South Square, Gray's Inn, London, WC1R 5EU,
United Kingdom

(54) Production system for subsea oil wells

(57) This invention presents a subsea production system in which a new concept of subsea structure for oil well drilling, completion and production was specially designed for utilization in water depths of 1,000m or more.

The structure includes a template having arms 2 which extend radially from a central foundation (3), and on top of which said structure the central manifold (31) for well production control is located. Each structure arm 2 is provided in its extremity with an opening for accommodating a guide-base for well drilling; and one of the arms (2') of the structure is intended to receive the connectors (6) for the export and well control lines.





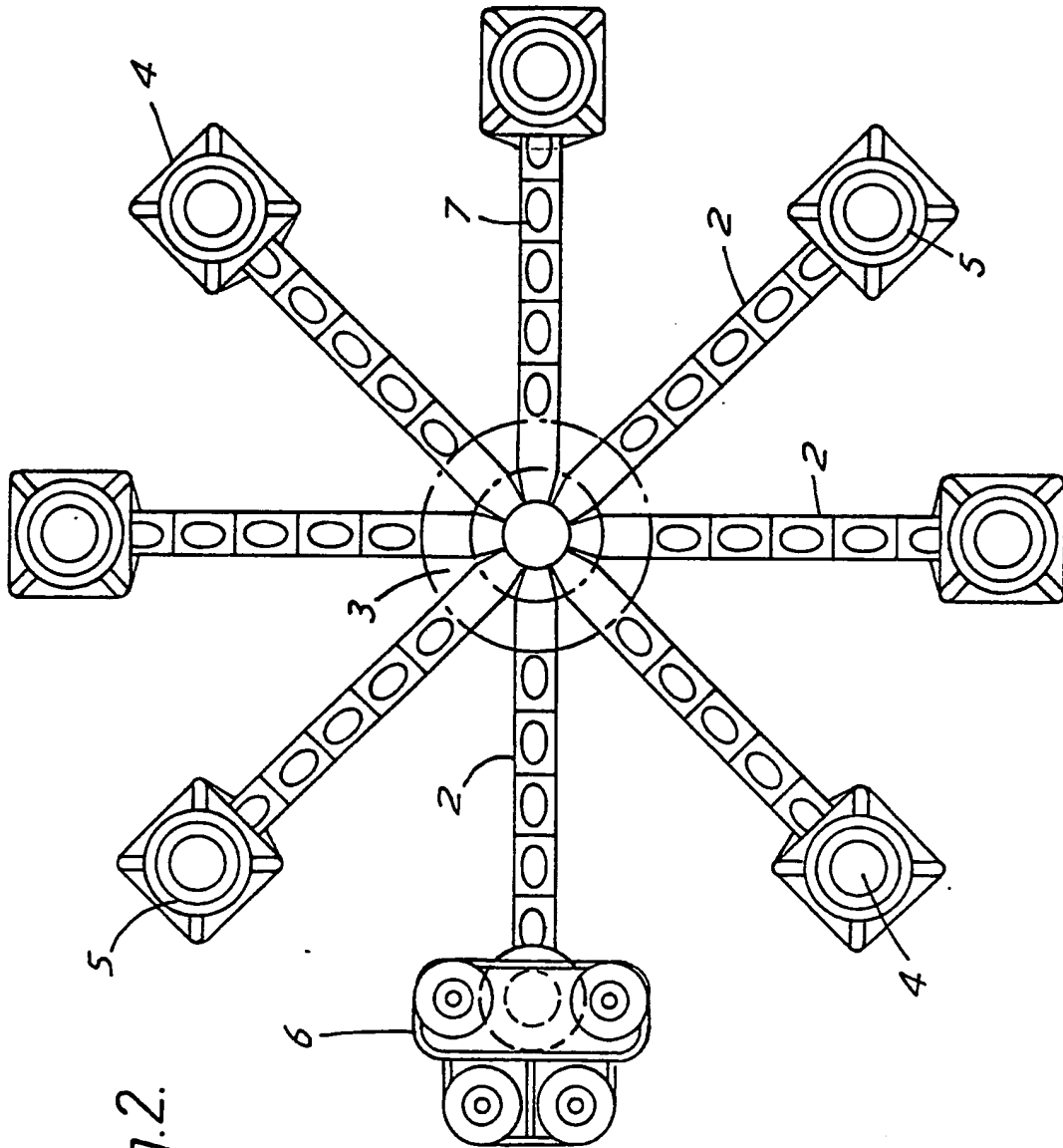
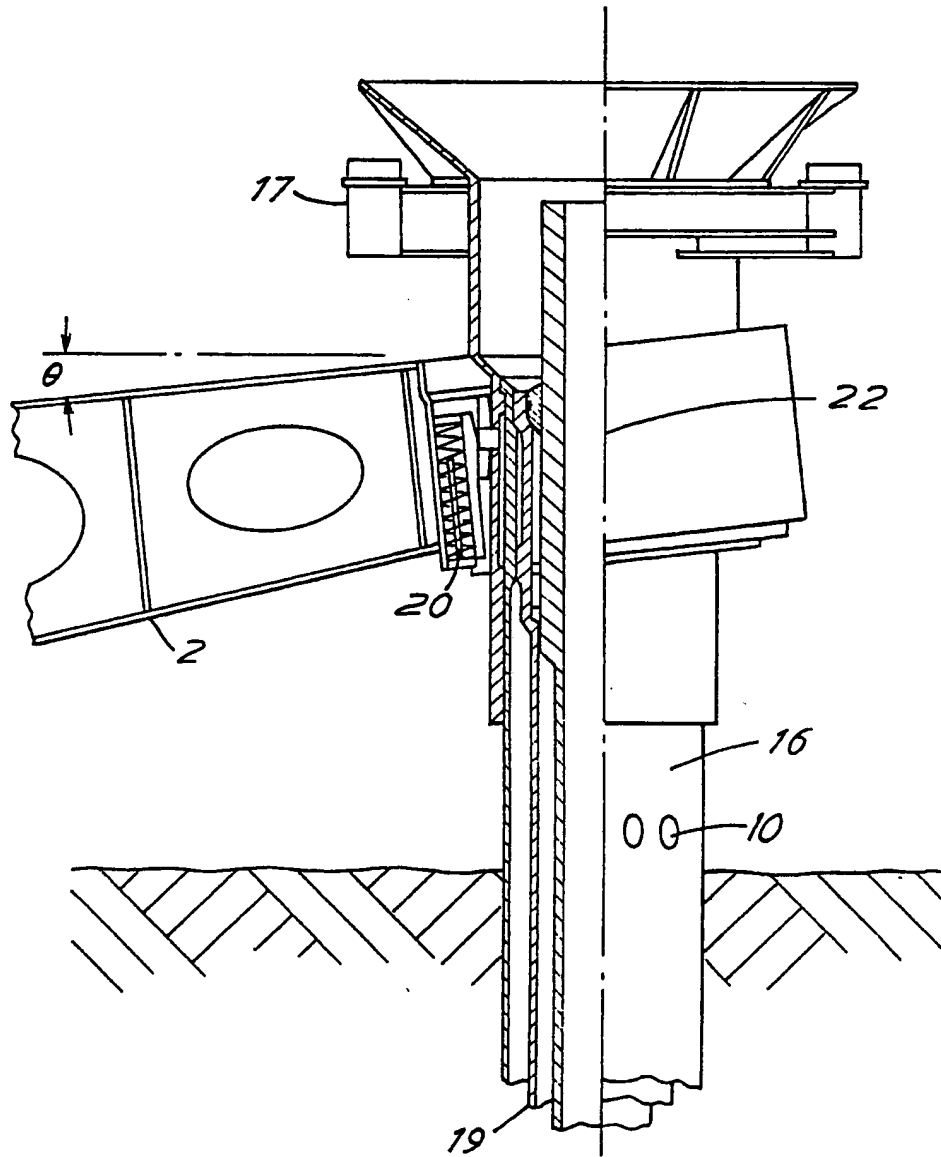


Fig.2.

Fig. 3.



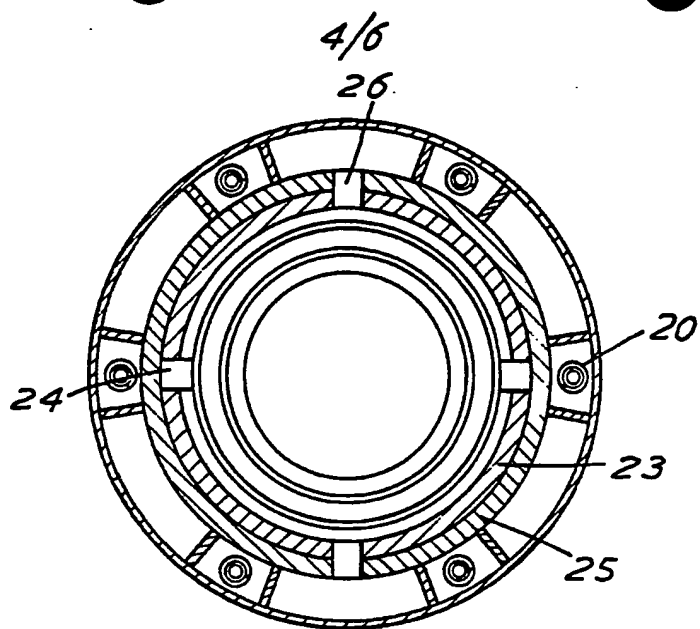


Fig. 4.

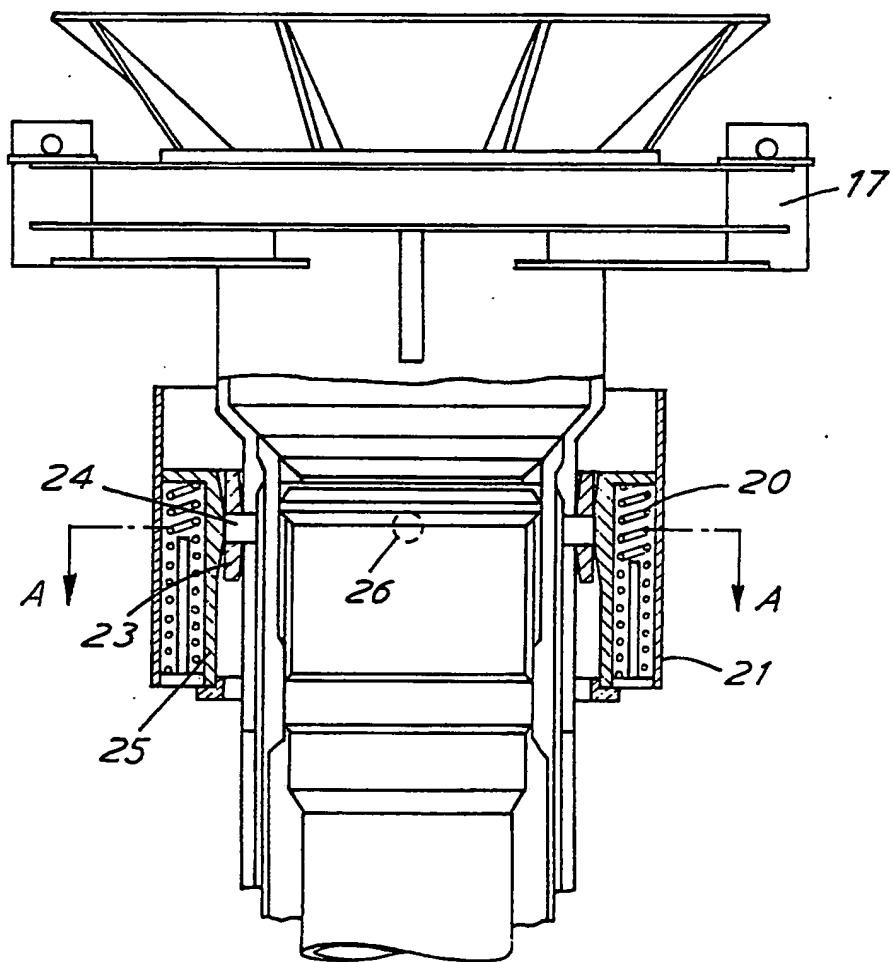


Fig. 5.

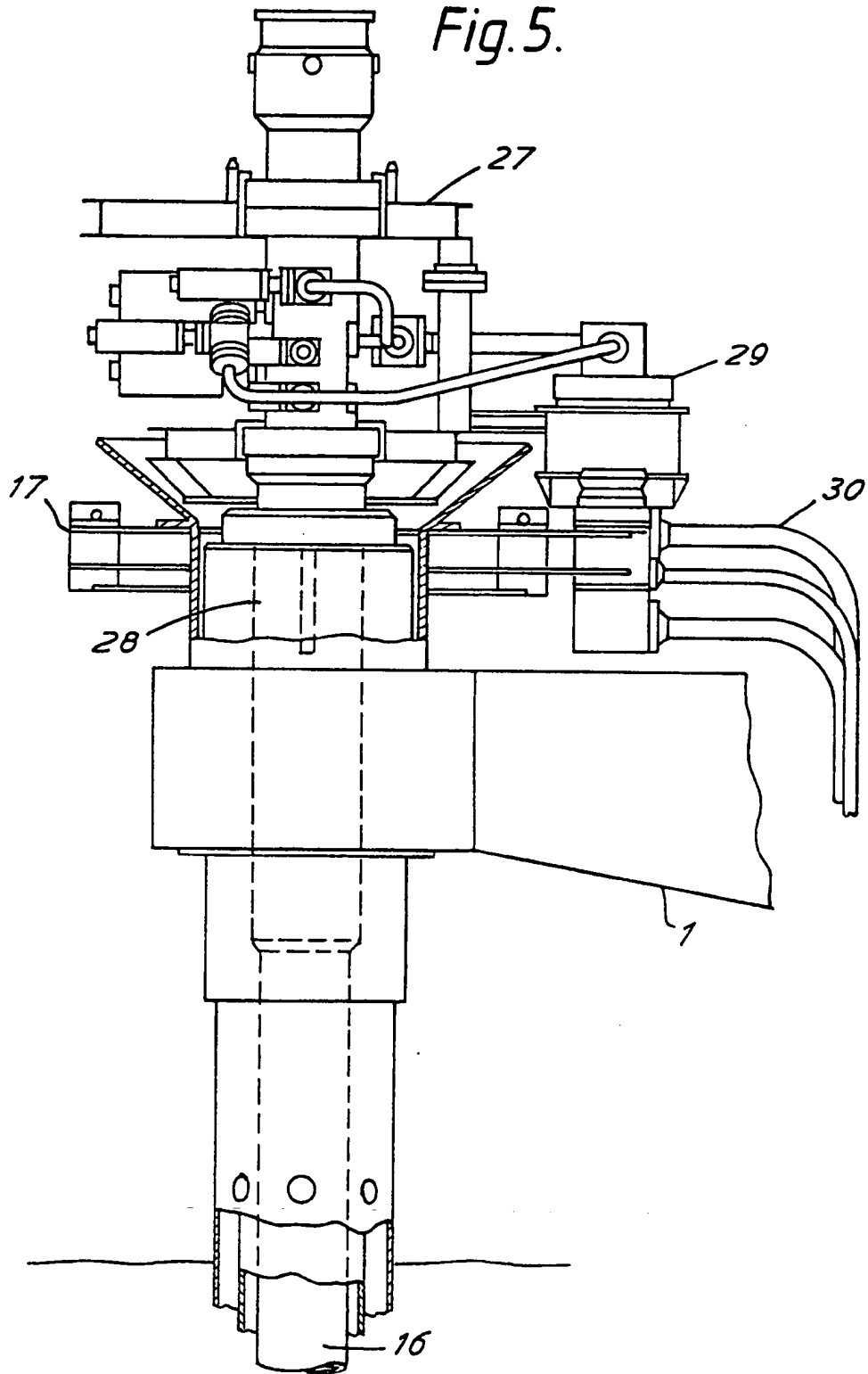
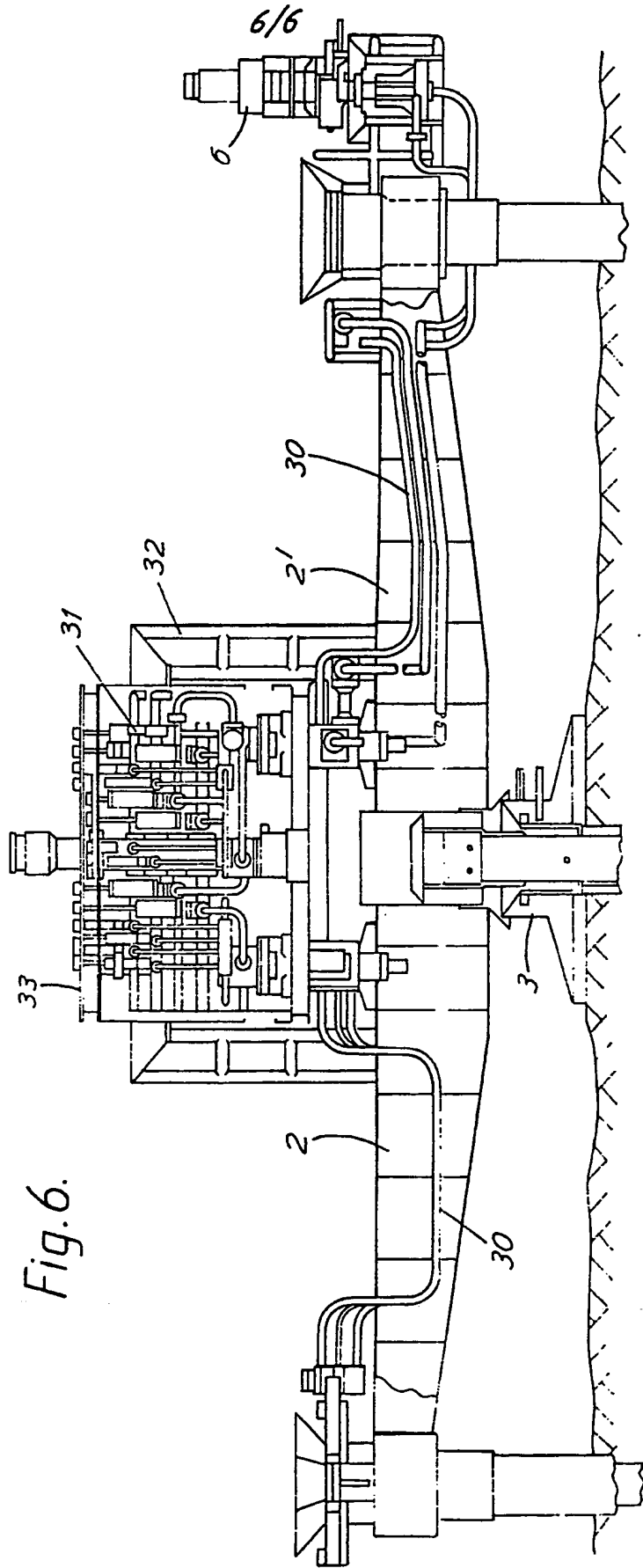


Fig. 6.



PRODUCTION SYSTEM FOR SUBSEA OIL WELLS

This invention relates to a production system for subsea wells, the main component of which is a subsea structure, of template-manifold type, specially developed
5 for use in production areas located at water depths of 1,000m or more.

Oilfield development in deep waters (water depths in excess of 400m) requires that the producing wells be subsea, which implies that the wellhead and the Christmas
10 tree shall be installed at the seabottom, slightly above the seabed.

For economic reasons, the usual practice for such oilfield development has been to group various wells into one single structure, which is set at the seabottom. This
15 structure is internationally known as a template. It includes, usually, a square or rectangular structure, to incorporate provision for a given number of wells which are spaced between themselves according to a pattern established by the American Petroleum Institute - API,
20 which sets 2.28m (7.5 ft) as the minimum distance between well centres.

In the 70's the oil industry started adopting subsea well production and wet Christmas trees were developed. In the beginning, the production from various
25 satellite wells was collected into one central manifold to be transported to floating storage or production units, or to fixed platforms.

With the discovery of major fields in water depths in excess of 400 m (the current limit for divers' assistance), the oil industry started adopting subsea
30 completion as an economically more feasible option for production development of said fields.

As a function of the specific characteristics of the producing reservoirs, the industry initiated the
35 establishment of new template concepts, so as to make

possible the existence of various producing wells in one single area and to facilitate collecting production to one single manifold, which may or may not be incorporated into the template. The term template manifold refers to
5 structures in which the manifold is associated with the template.

The currently known subsea template manifolds include structures containing the guide-bases, on top of which are installed the wellheads and the Christmas trees,
10 as well as the manifold which collects the well production.

Bearing in mind that the distance between wells complies with international standards, and is not large in relation to the dimensions of the equipment to be installed, it is easy to anticipate the operational and
15 safety difficulties which must be faced in placing the wells in the production condition.

From an operational point of view, it must be considered that the template structure is usually very heavy, requiring a special foundation, a piling system, and
20 rigorous levelling, in order to make well drilling and a perfect installation of Christmas trees possible. Most structures are provided with their own levelling system, the acceptable misalignment in relation to the horizontal being of the order of 1 degree.

25 Installing those structures at the seabottom requires the use of major lift units and good sea conditions. The operational cost of those units is rather high, and the installation operation is rather time-consuming.

30 Another problem which usually occurs, even in those structures which are installed in an elevated position in relation to the seabottom, is the deposition of drilling waste around already completed wells, and this may require expensive and difficult cleaning operations, particularly
35 in case of deep-water operation.

From a safety point of view, the difficulties are still greater. The operations conducted on the template, whether drilling (the most time-consuming) or completion, call for high accuracy. The fact of working at large water depths and having the tools at the end of the string (BOP's, packers, wellheads, connectors, Christmas trees, etc.) turns operations such as casing running, connection, coupling, into tasks which are rather difficult to be conducted with the required accuracy. Considering the fact that all wells are concentrated within one single "box", it is easy to understand the risk of shock between equipment units which arises when installing a BOP or a Christmas tree (heavy, large equipment) where other already drilled or completed wells exist.

GB-A-2003533 discloses a structure designed to solve the above described problems of weight, transportation and installation. It is a floating template which comprises a central structure, out of which extend arms which fold onto the central structure during transportation; at the end of each arm is a conventional template, and the central structure can itself be used as a template. The structure is set at the seabottom by means of controlled flooding of the piping which constitutes the structure.

As may be verified, the problem of spacing between wells and operational safety were not solved.

The FR-A-2440997, describes a subsea production system in which a number of individual (satellite) wells, drilled in different locations in the field, have their production gathered into a production collecting device, installed at the seabottom at a position within the assembly of wells; individual well production is taken to a manifold installed in a submersible platform by means of export lines which are put together as a bundle of lines rising from the seabottom to the platform. The crude oil

returns to the seabottom through a pipeline inside the bundle and is thereafter taken up to a pivoting buoy, for the purposes of loading the tankers.

5 Connection between the producing wells and the central production collecting device is achieved by means of connection lines supported by elongate articulated structures which are supported at the seabottom and which converge into a central point which serves as the base for the production collecting device. Thus, the elongate
10 structures which support those connection lines have, at one of their ends, a guide for the well to be drilled and, at the other end, a central base face which supports the production collecting device.

The system described in the FR-A-2440997 partially
15 solves some of the problems pointed out above, but the operational difficulties (particularly those relating to connection point alignment and tool connection) remain unsolved since the problems arising from seabed irregularities were not taken into account.

20 One object of this invention is to provide a subsea production system which includes a subsea template structure for use in very deep waters, which must be light and offer higher operational flexibility.

Another object of this invention is to provide a
25 structure which is simpler, and more economical, than hitherto, and does not suffer major setting limitations due to seabottom irregularities.

According to the present invention we provide a production system for subsea oil wells located in deep
30 waters, including a central foundation; and a template structure on top of said central foundation so as to be maintained clear of the seabed; wherein the central production control manifold of the oil wells is located on top of said template structure; wherein the template
35 structure has arms extending radially outwardly from said

central foundation, each of which arms is provided at its extremity with an opening for receiving a guide-base, which allows for drilling of a well and attachment of said template structure; and wherein one of said arms of said
5 template structure is intended to receive the connectors for the export and well control lines.

The invention thus provides a new concept of subsea structure for oil well drilling, completion and production, the structure being capable of adaptation for use in water
10 depths of 1,000m or more.

Such a subsea production system, including a template structure, can allow for a larger spacing than hitherto between wells, thus increasing safety in operation and reducing tool impact risks during setting of the wells.
15 The subsea production system, with the template structure for oil well drilling and completion, allows for the use of remote-operated vehicles (ROV's) during those operations in which their use is required.

In order that the present invention may more readily be understood the following description is given, merely by way of example, reference being made to the accompanying drawings, in which:-
20

FIGURE 1 is a side view, partially in section, of subsea structure included in a subsea production system according to the invention, set onto the central
25 foundation;

FIGURE 2 is a top plan view of the structure, showing eight guide-bases at the ends of its arms, of which seven arms are for the subsea wells and one is for the
30 installation of connectors of the export and control lines;

FIGURE 3 is a side view, partially in section, of a subsea well with its guide, and the possibility of relative movement between the well guide and the template structure of the invention is shown;

35 FIGURE 4 shows in detail the supporting system of

the well guide;

FIGURE 5 is a side view, partly in section, of a well located in one of the structure ends, in which the Christmas tree and the respective connections and transfer lines have been already installed; and

FIGURE 6 represents a side view of the central production control manifold, already installed on the template.

As previously described, one of the difficulties faced in the phase of subsea well drilling relates to the deposition of the well drilling waste within the template structure and onto the image-taking points, thus preventing monitoring operations by means of TV sets at the surface.

The subsea structure according to this invention, being a more transparent and more elevated structure, prevents the accumulation of drilling waste within it, since the return points of well drilling waste are located below the level of the structure.

From an economic point of view, the structure offers some advantages which will become immediately evident. Being a lighter structure, it is less expensive since it requires less raw material and does not call for the use of a major crane for its installation. Not requiring a more accurate levelling system, its foundation can be simpler, which also makes it expensive.

As can be seen in Figures 1 and 2, the subsea structure includes a template 1 with arms 2 extending radially from a central foundation 3, on top of which are set the template 1 and the central control manifold 31 (not shown in these Figures). At the end of each arm 2 of the template 1 is an opening 4 for adaptation of guides 5 intended for well drilling.

Figure 2 shows, in plan view, a structure with eight arms, of which seven are intended for well drilling, whereas one is reserved to receive the connectors 6 for the

export and well control lines. However, neither the box girder beam construction of the arms 2 as shown in the Figures, nor the number of the arms, are limiting factors of the invention. The structure can be adapted for as many
5 arms as desired, observing only the general template design which reserves one of the structure arms for the installation of the connectors 6 and joins them to the central control manifold 31.

10 The void spaces 7 in the structure are intended to reduce its weight, which is usually large in box-type beams, as well as to make the structure more transparent.

One advantage of the structure of the invention is that its installation requires only conventional tools and techniques which are widely known to the experts in the
15 art.

Thus, returning to Figure 1, the central foundation 3 is an assembly of well-known elements. A temporary guide base (TGB) 8 is set at the seabed together with a pile 9 by a jetting technique, the pile being maintained rigidly
20 attached to the TGB 8 by means of a housing, welded to said pile 9 and clamped by means of bolts.

The whole installation operation of the central foundation 3 is monitored at the surface by means of closed circuit TV, so as to ensure appropriate levelling
25 conditions. For that purpose, a level-indicating instrument 11 is located at the TGB 8 well above the drilling waste outlet and return orifice 10, thus preventing deposition of drilling waste onto the level indicator 11.

30 The maximum allowed misalignment of the internal foundation relative to the vertical is 2 degrees, since it is limited to the play allowed for tool connection at the time of well drilling and completion.

Similarly to the technique used in oil well
35 drilling, a conductor pipe 12 is run inside the pile 9, and

is cemented and set by means of another housing on top of which is installed a second base 13 for the purposes of setting the template 1. With this elevation of the template structure 1, the problem of deposition of drilling waste within it is also solved.

The fact of the structure 1 being maintained in an elevated position in relation to the seabed, set onto only the central foundation 3 and, as will be seen later on, supported by the guides in the end of each arm 2, for the wells being drilled, ensures that deposition of drilling waste occurs around the wells and does not prevent the monitoring of the operations at the surface.

Another advantage of the subsea structure of the present invention is that it does not constrain the drilling, completion, or production operations to one single technique. For instance, well drilling can be conducted using both guide-bases provided with guide-posts and guide-cables 14, or guide-bases provided with guide-funnels 15, depending upon the type of rig which is available.

However, whatever the choice, the ends of the arms 2 of the template structure 1 are provided with guides 5 for the wells 16, all of these guides provided with a housing 17 for remote post connection in case it is desired to change the system, in for instance the production phase, and also to serve as a support for the installation of flowline connectors, as will be described later.

In the one arm 2' reserved for the installation of the connectors 6 for the export and well control lines, the guide 5 is used to install a foundation for supporting the structure 1.

Figure 3 shows one of the ends of an arm 2 of the template, through which a well 16 is being drilled. The wells are drilled through the guides using conventional techniques, and following the standard operational sequence

up to wellhead installation.

One relevant aspect of the invention relates to the supporting system 22 on the template structure 1 for the guides 5 for the wells.

5 The pile 18 and the surface casing 19 are dimensioned to withstand most stresses which occur at the wellhead, and to minimize the amount of said stresses transferred to the template structure 1 and, consequently, to the central foundation 3. This result is achieved by
10 means of a spring system 20, shown in detail in Figure 4, located at the interface of the well guide 5 with the template structure 1. This spring system 20 makes it possible to monitor those mentioned stresses through visual inspection on a TV system, correlating the deflection
15 experienced by the spring system 20 to the displacement verified in a graded rod inserted in said spring system.

The invention also provides for a knuckle-joint supporting system, which allows for considerable variations between the inclinations of the well 16 and of the template
20 structure 1, that is, it makes it possible to drill the well within inclinations admissible for tool connection, regardless of the inclination of the template structure relative to the horizontal.

In practice, a maximum limit of the order of 6
25 degrees was adopted for the angle of inclination θ . This was considered sufficient to compensate for the operational difficulties of drilling a perfectly vertical well. This limits the deflection due both to the inclination θ of the template and to the inclination of the well. However,
30 values of θ in excess of 6° can be easily achieved with the correct positioning of elements restricting movement of the knuckle-joint.

Such characteristics are not present in the templates known to date and ensure the enhanced operational
35 flexibility and safety identified above as objects of the

subsea structure of the invention, making it highly advantageous in relation to the structure so far known for this purpose.

Figure 4 shows in detail the spring system 20 for well guide support 22. Once the pile 18 is set, it is clamped to the well guide 5 by means of an internal ring 23 attached thereto by means of two pins 24 which are aligned with the longitudinal axis of the arm 2 of the template structure 1. Thus, the movement of the well guide 5 around this longitudinal axis shall be free, whether through the application of roller bearings to the pins 24 or through the utilization of a ring 23 in which the housing for the pins is larger than their diameter.

The internal ring 23 transfers the stress to the template structure 1 by means of a second ring 25 traversed by two other pins 26, located in the same plane as the two above-mentioned pins 24, and aligned with an axis perpendicular to the longitudinal axis of the arm 2 of the template structure 1, allowing for the rotation of the set also about this perpendicular axis. As a consequence, combining the movement around those two axes, it is possible to align the wellhead with the vertical, regardless of the inclination θ prevailing at the template structure 1, provided the inclination θ is maintained within the specified limits by means of the knuckle-joint supporting system 22.

Although the possibility of a relative movement between the well guide 5 and the template structure 1 offers a major advantage, it also poses some difficulties concerning guaranteeing of the tolerances required for the perfect connection of the Christmas trees to be installed during the well completion phase. This problem can be easily overcome through the installation of the flowline connectors 29 of the wells at the same level as the well guide 5, where the housings 17 for remote post connection

are located. This embodiment shall become clearer with reference to Figure 5.

Figure 5 shows an end of the template structure 1 at which a well has been drilled and completed, and the connections have been made.

As the Christmas tree 27 is lowered in the well 16, it must be simultaneously attached to (i) the high-pressure housing 28 from where it will receive the oil produced, and (ii) the flowline connector 29 of the tree 27 through which it shall send the oil produced to the central manifold 31, by means of lines 30 specially dimensioned for this purpose. The central manifold is shown in Figure 6, as will be described later.

Since the flowline connector 29 is located in the same level where the slots 17 for guide-post installation are located, the movement of the flowline shall be identical to that of the well guide 5, since both parts become rigidly attached together. Thus, the relative positioning between the connection points of the Christmas tree 27 becomes perfectly controlled, since the inclination of the well guide 5 is controlled by the inclination of the well 16 itself.

The freedom of movement afforded to the flowline connector 29 of the Christmas tree 27 relative to the template structure 1 is easily absorbed by the transfer lines 30, which are long enough to admit strains which compensate for variations in the relative positioning of the parts.

Figure 6 shows in detail the central manifold 31 which, although it is installed jointly with the template structure 1, presents the characteristic of being removable therefrom.

The possibility of removing the central manifold 31 represents a major advantage of the invention, since in the event of casual accidents and/or equipment defects the

repairs can be more easily performed.

Since the central manifold is located at equal distance from the wells, it is for higher system safety surrounded by a protection screen 32 and presents in its upper portion a fenced platform 33 which covers the central manifold 31 and allows for settling of remote operation vehicles, thereby facilitating valve identification and also the access for minor repairs.

One way of reducing the failures due to manifold malfunctioning, which has been adopted in this invention, consists in concentrating the active flow elements (valves and chokes) in the Christmas trees 29 and leaving to the central manifold 31 only passive elements such as piping or some valves intended for occasional operation and which can be driven by means of remote-operation vehicles, etc.

The configuration of the central manifold 31 may vary according to its purpose, assuming different geometries and functions in accordance with the purpose to be achieved. The manifold illustrated on Figure 6 has been dimensioned for control of seven wells. As previously mentioned, the export and control connectors 6 are installed at the end of one of the arms 2' of the template structure 1. The number of connectors required is determined so as to meet the particular characteristics of the exploitation project of a given oil field, and each connector can work with more than one line.

Although the above description has been based on one embodiment illustrated in the drawings, it is possible to introduce modifications which will often be evident to those skilled in the art and which have not been elucidated herein, without deviating from the scope of the invention. Thus, the Figures included in this specification have a purely illustrative character and should not limit the invention in any way.

C L A I M S

1. A production system for subsea oil wells located in deep waters, including a central foundation; and a template structure on top of said central foundation so as to be maintained clear of the seabed; wherein the central production control manifold of the oil wells is located on top of said template structure; wherein the template structure has arms extending radially outwardly from said central foundation, each of which arms is provided at its extremity with an opening for receiving a guide-base, which allows for drilling of a well and attachment of said template structure; and wherein one of said arms of said template structure is intended to receive the connectors for the export and well control lines.
2. A production system for subsea oil wells according to claim 1, wherein said template structure utilizes a spring system with knuckle-joint support for the guide for a said well, to transfer the stresses occurring at the wellhead to the central foundation of the template structure.
3. A production system for subsea oil wells according to claim 2, wherein said knuckle-joint supporting system makes it possible to drill the well within the admissible inclination for tool connection, regardless of the inclination of the template structure.
4. A production system for subsea oil wells according to claim 2, wherein said knuckle-joint supporting system allows for inclinations of the template structure of the order of 6 degrees relative to the horizontal.
5. A production system for subsea oil wells according to any one of claims 1 to 4, wherein the flowline connectors of the wells are installed in the template structure at the same level as the well guide so that the relative positioning of the points of connection to the Christmas tree is maintained.

6. A production system for subsea oil wells according to any one of claims 1 to 5, wherein the central manifold is removable, and located in the centre of and on said template structure, and is attached to the connectors
5 for the export and well control lines, said connectors being concentrated in one end of one of the arms of said template structure.

7. A production system for subsea oil wells, constructed and arranged substantially as hereinbefore
10 described with reference to, and as illustrated in, the accompanying drawings.